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09/997,162	11/29/2001	Jerome J. Cuomo	297/104/2	3621

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Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary	Application No. 09/997,162	Applicant(s) Cuomo et al.
	Examiner Rodney McDonald	Art Unit 1753

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136 (a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1) ☐ Responsive to communication(s) filed on _____.

2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.

3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11; 453 O.G. 213.

Disposition of Claims

4) ☒ Claim(s) *1-54* is/are pending in the application.

4a) Of the above, claim(s) *46-54* is/are withdrawn from consideration.

5) ☒ Claim(s) *1-45* is/are allowed.

6) ☐ Claim(s) _____ is/are rejected.

7) ☐ Claim(s) _____ is/are objected to.

8) ☐ Claims _____ are subject to restriction and/or election requirement.

Application Papers

9) ☐ The specification is objected to by the Examiner.

10) ☐ The drawing(s) filed on _____ is/are a) ☐ accepted or b) ☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

11) ☐ The proposed drawing correction filed on _____ is: a) ☐ approved b) ☐ disapproved by the Examiner.

If approved, corrected drawings are required in reply to this Office action.

12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

13) ☐ Acknowledgement is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a) ☐ All b) ☐ Some* c) ☐ None of:

1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. _____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

*See the attached detailed Office action for a list of the certified copies not received.

14) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. § 119(e).

a) ☐ The translation of the foreign language provisional application has been received.

15) ☐ Acknowledgement is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

1) ☒ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s). 8
4) ☐ Interview Summary (PTO-413) Paper No(s). _____
5) ☐ Notice of Informal Patent Application (PTO-152)
6) ☐ Other:

DETAILED ACTION

Election/Restriction

1. Restriction to one of the following inventions is required under 35 U.S.C. 121:

   I. Claims 1-45, drawn to an apparatus and method, classified in class 204, subclass 192.1+.

   II. Claims 46-54, drawn to a product, classified in class 428, subclass 1+.

2. The inventions are distinct, each from the other because of the following reasons: Inventions I and II are related as process of making and product made. The inventions are distinct if either or both of the following can be shown: (1) that the process as claimed can be used to make other and materially different product or (2) that the product as claimed can be made by another and materially different process (MPEP. § 806.05(f)). In the instant case the product as claimed can be made by another and materially different process such as chemical vapor deposition.

3. Because these inventions are distinct for the reasons given above and have acquired a separate status in the art as shown by their different classification, restriction for examination purposes as indicated is proper.

4. During a telephone conversation with David Gloekler on February 27, 2003 a provisional election was made with traverse to prosecute the invention of Group I, claims 1-45. Affirmation of this election must be made by applicant in replying to this Office action. Claims 46-54

withdrawn from further consideration by the examiner, 37 CFR 1.142(b), as being drawn to a non-elected invention.

5. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(I).

Claim Rejections - 35 USC § 102

6. The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

> A person shall be entitled to a patent unless -
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of application for patent in the United States.

7. Claims 1, 2, 4, 6, 7, 9, 14, 18, 22, 24, 43 and 44 are rejected under 35 U.S.C. 102(b) as being anticipated by Mikalesen et al. (U.S. Pat. 4,824,544).

An etching/deposition system comprising ***a hollow cathode electron source*** in combination with a magnetron sputter deposition plasma device within a containment chamber, ***said hollow cathode being disposed to inject electrons into the magnetic field of the magnetron plasma device adjacent to the magnetron cathode surface to which a deposition source is affixed.*** Said system further includes means for initiating and maintaining a discharge plasma within the hollow cathode and for initiating and maintaining the magnetron plasma. The

improvement of the invention comprises a workpiece to be coated, located in said chamber, spaced from said magnetron cathode surface which may be biased to attract particles emitted by said deposition source. A particle collimation filter is interposed between the magnetron cathode surface and said target sample but outside of said plasma region, which prevents any deposition particles from reaching said target sample which are not traveling in a direction substantially perpendicular thereto. (See Abstract)

The present invention is based on the use of a hollow cathode enhanced magnetron sputtering system described previously. A cross-sectional view of the improved sputtering system of the present invention is shown in FIG. 1. The apparatus consists of a conventional magnetron 1. ***The magnetron target 10 is placed on a magnet assembly 12*** which consists of a central pole 13 of one magnetic polarity, and ***a circular*** outer pole 14 of the opposite polarity. Magnetic field lines 15 are shown connecting the two poles. The strength of the magnetic field is related to the density of these virtual field lines 15. The magnetron target 10 is biased by up to several hundred volts negative by ***magnetron power supply 16***. For RF operation the ***DC power supply 16*** would be replaced with an RF power supply and a suitable matching network as is well known in the art. An RF power supply would be used if the deposition source were an insulator such as quartz. The disclosed embodiment of the ***chamber 17*** functions as the anode, although a separate anode closer to the target 10 could be used. ***The chamber 17 also functions as a vacuum vessel.*** (Column 4 lines 1-25) DC source 16 biases the target negatively as seen in Figure 1. (Figure 1) ***The cathode is circular due to the circular nature of the magnet 14.*** (See Above)

A critical aspect of the present hollow cathode enhanced magnetron is the coupling between the hollow cathode plasma and the magnetron plasma. The coupling of the two devices depends critically on the relative positioning of the hollow cathode or multiple hollow cathodes with respect to the magnetron cathode. ***One example of a suitable position for the hollow cathode is shown in FIG. 1 for the disclosed planar magnetron. In this case, the hollow cathode 20 and insulator 21 are mounted below the magnetron target 10, close to the outer edge, and projecting horizontally in towards the magnetron's center.*** The radial position of the hollow cathode 20 must be such that the intersected magnetic field lines traverse the cathode face and intersect the center pole 13. (Column 4 lines 26-40) ***From Figure 1 the hollow cathode is negatively biased by the dc power source. A background gas is inletted into the chamber through the hollow cathode.*** (See Figure 1)

The function of the tube array 34 is to produce a collimated flux of the sputtered material, shown in the figure by the reference numeral 38. This material then impinges or lands upon the samples 40 which are placed ***on the substrate platform 42.*** Although the platform, is shown as fixed on the supports 44 it is probable that there would need to be some movement capabilities for the platform in order to obtain completely uniform films and or deposit on a large number of workpieces. (Column 5 lines 14-22)

A still further use of the array is in the area of reactive deposition. In this case, the array functions as a conductance block for reactive species introduced at the sample surface from contaminating the target surface. This reduces the poisoning of the cathode which usually results

in low sputtering rates. ***Such a reactive gas source 50 is shown in FIG. 1 entering the chamber 17 near the workpiece.*** (Column 6 lines 10-17)

The material to be deposited can include semi-conductor metal layers, insulators, etc., (Column 1 lines 31-32) These are films for many substrates 40. (Figure 1)

Claim Rejections - 35 USC § 103

8. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

> (a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103© and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

9. Claims 1-12, 14, 18, 22-24, 28-30, 35, 43 and 44 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikalesen et al. (U.S. Pat. 4,824,544) in view of Cuomo et al. (U.S. Pat. 4,588,490).

Mikalesen et al. is discussed above and all is as applies above. (See Mikalesen et al. discussed above)

The differences between Mikalesen and the present claims is the kind of reactive gas supplied (claim 3), utilizing argon gas (claim 5), utilizing a rectilinear configuration (claims 8, 23, 30), the target material (claim 9), the target material being aluminum (Claims 10 and 11), the target being zinc (claim 12), the material of the target holder (Claim 17), biasing the substrate holder (Claim 26), the material of the injector being of different material than the target (claim 28), the circular configuration of the injector (claim 29) and the plurality of injectors (claim 35).

Cuomo et al. teach a plasma sputter etching/deposition system comprising an electron-emitting hollow cathode arc-source combined with a conventional plasma sputter etching/deposition system such as a magnetron. The electrons emitted are coupled into the intrinsic high energy, e.g., magnetic field and are accelerated by the plasma potential and cause a significant increase plasma density. The resultant combination allows much greater sputtering/deposition efficiency than was possible with previous devices. According to a further aspect of the invention, switched operation is possible, whereby etching may vary from isotropic to anisotropic. A side discharge hollow cathode structure is also described for enhancing certain sputtering/deposition processes, wherein electrons may be emitted from one or more openings at the side of a hollow cathode chamber to achieve more uniform electron emission in a large process chamber. (See Abstract)

A hollow cathode is a plasma device which is capable of emitting a high electron current. The actual operating procedure is well known and has been described in detail in the (H.R.Kaufman, R. S. Robinson and D. C. Trock, "J. Spacecrafts and Rockets," Vol. 20, (1983), p 77), and will not be repeated here. By biasing the hollow cathode sufficiently negative of some anode, a plasma can be produced due to electron ionization of the background (working) gas. This plasma is characterized by a discharge current, which is also equal to the emission current of the hollow cathode. With even a small hollow cathode of diameter 1/8 inch, discharge currents of up to 15 amps are possible at pressures in the ***0.2-0.6 millitorr range in Argon***. (Column 2 lines 37-50)

One example is ***nitride*** formation. A depositing film of ***aluminum*** in ***a nitrogen background pressure*** will not form ***aluminum nitride*** as discussed in J. M. E. Harper, J. J. Cuomo and H. T. G. Hentzell, Appl. Phys. Letter, 43, (1983) p 547. It is necessary to bombard the aluminum film with energetic nitrogen to induce the reaction to occur. The enhanced magnetron can be used to provide high current density nitrogen bombardment in this case to a depositing film at ion energies below the sputter threshold, as to not remove any of the film. Thus, very high rate compound film formation can occur by inducing chemical reactions at ***the target (i.e. target of aluminum)*** surface of the enhanced magnetron. (Column 8 lines 65-68; Column 9 lines 1-10)

Additional cathode structures might include a circular or bent tube having a series of holes in one side to give the effect of multiple cathodes in the same plane as in a simple

circular gas stove burner. Also a planar hollow cathode structure is envisioned which would comprise a flat hollow structure having a plurality of holes on one-one side thereof and having sheets of electron emissive foil inside together with suitable openings for sustaining ionizable gas flow. (Column 11 lines 62-68; Column 12 lines 1-2)

While most of the description of the preferred embodiment of the present invention has been directed to magnetron plasma devices, it is to be understood that the hollow cathode enhancement concept would apply equally well to plasma sputter etching/deposition systems including magnetron, RF diode (DC), ion beam and also to ion plating systems. And further, the present concept allows the combining of two otherwise incompatible systems in a single process chamber. (Column 12 lines 26-34)

Ionizable gas is introduced into the system. (Column 12 line 62) The device deposits metals. (Claim 12) (Column 12 lines 5-9) The target holder can be metal. (See Figure 1) ***A refractory material is utilized as the tip of the hollow cathode.*** (Column 2 lines 63-66)

The magnetron can be rectangular thus the cathode can be rectangular or rectilinear. (Column 6 lines 40-42)

The motivation for utilizing the parameters as set forth by Cuomo et al. is that it allows increasing the magnetron current during sputtering. (Column 4 lines 27-30)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Mikalesen et al. by utilizing the kind of reactive gas supplied, utilizing argon gas, utilizing a rectilinear configuration, utilizing a specific target

material, utilizing a specific target holder material, biasing the substrate holder, utilizing the material of the injector to be a different material than the target, utilizing a circular configuration of the injector, utilizing a plurality of injectors as taught by Cuomo et al. because it allows for increasing the magnetron current during sputtering.

10. Claims 13, 19, 20 and 21 are rejected under 35 U.S.C. 103(a) as being unpatentable over Mikalesen et al. in view of Cuomo et al. as applied to claims 1-12, 14, 18, 22-24, 28-30, 35, 43 and 44 above, and further in view of Moslehi (U.S. Pat. 5,876,573).

The differences not yet discussed is the circulation of the heat transfer medium.

Magnet assembly housing 116 includes cooling channels 120. As shown, cooling channels 120 are positioned above a magnet assembly 122. A space 124 is established between magnet assembly 122 and magnet assembly housing 116. Space 124 can be filled with liquid having a low-vapor-pressure to communicate cooling and heating by water in cooling channels 120 to target 112. The low-vapor-pressure liquid can comprise mercury or gallium such that the liquid does not evaporate at reduced pressure inside the assembly. This will provided complete liquid thermal contact between the magnet assembly housing 116 and insulation disk 114 for increased cooling. In this embodiment, the cooling channels 120 are formed in magnet assembly housing 116 instead of the backing plate. (Column 8 lines 39-52)

The motivation for circulating heat transfer medium is that it allows for increasing cooling. (Column 8 lines 39-52)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have utilized coolant as taught by Moslehi et al. because it allows for increasing cooling.

11. Claim 25 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mikalesen et al. in view of Cuomo et al. as applied to claims 1-12, 14, 18, 22-24, 28-30, 35, 43 and 44 above, and further in view of Teer (U.S. Pat. 5,556,519).

The differences not yet discussed is the use of unbalanced magnetrons.

Teer teach the use of unbalanced magnetrons as seen at Column 5 lines 40-60.

The motivation for utilizing an unbalanced magnetron is that it allows for increasing the intensity of ionization. (Column 2 lines 16-18)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have utilized an unbalanced magnetron as taught by Teer because it allows for increasing the intensity of ionization.

12. Claim 26 is rejected under 35 U.S.C. 103(a) as being unpatentable over Mikalesen et al. in view of Cuomo et al. as applied to claims 1-12, 14, 18, 22-24, 28-30, 35, 43 and 44 above, and further in view of Helmer et al. (U.S. Pat. 5,482,611).

The differences not yet discussed is providing a negative bias to the substrate.

Helmer et al. teach that to improve the ability of a sputter source to fill grooves and vias has been to apply an rf bias to the wafer substrate, thereby causing a negative charge to buildup in a know manner. The negative charge causes gas ion in the sputter chamber to bombard the wafer

imparting a degree of surface mobility to the deposited aluminum atoms causing them to spread out along the surface. (Column 3 lines 2-8)

The motivation for applying a negative voltage to a substrate is that it allows the metal atoms to take on a degree of mobility to fill grooves and vias. (Column 3 lines 2-8)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have utilized a negative bias as taught by Helmer et al. because it allows for metal atoms to take on a degree of mobility to fill grooves and vias.

Allowable Subject Matter

13. Claim 42 is allowed.

14. The following is a statement of reasons for the indication of allowable subject matter:

Claim 42 is allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including an electron/plasma injector assembly adapted for nonthermionically supplying plasma to a reaction chamber, the injector assembly comprising: a main body having a generally annular orientation with respect to a central axis and including a process gas section and a cooling section, the process gas section defining a process gas chamber and the cooling section defining a heat transfer fluid reservoir; and a plurality of gas nozzles removably disposed in the main body in a radial orientation with respect to the central axis and in heat transferring relation to the heat transfer fluid reservoir; each gas nozzle providing fluid communication between the process gas chamber and a region exterior to the main body.

15. Claims 15-17, 27, 31-34, 36-41 and 45 are objected to as being dependent upon a rejected base claim, but would be allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims.

Claims 15-17 are allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including where the target cathode holder is cup-shaped and the target cathode comprises a liquid-phase component.

Claim 27 is allowable over the prior art of record because the prior art record does not teach the claimed subject matter including where the injector assembly is constructed from the same material as the target cathode.

Claims 31-33 are allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including where each injector of the injector assembly includes a replaceable nozzle.

Claim 34 is allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including comprising an injector assembly holder secured to the injector assembly and adapted to circulate a heat transfer medium to remove heat from the injector assembly.

Claim 36 is allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including the injector assembly comprising a main body having a generally annular orientation with respect to a central axis and including a process gas section and a cooling section, the process gas section defining a process gas chamber and the cooling section

defining a heat transfer fluid reservoir; and a plurality of gas nozzles removably disposed in the main body in a radial orientation with respect to the central axis and in heat transferring relation to the heat transfer fluid reservoir; each gas nozzle providing fluid communication between the process gas chamber and a region exterior to the main body.

Claims 37-41 are allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including a containment shield and a containment magnet, the containment shield disposed between the target cathode and the substrate holder and the containment magnet disposed adjacent to the containment shield.

Claim 45 is allowable over the prior art of record because the prior art of record does not teach the claimed subject matter including the injector assembly comprising a main body having a generally annular orientation with respect to a central axis and including process gas section and a cooling section, the process gas section defining a process gas chamber and the cooling section defining a heat transfer fluid reservoir; and a plurality of gas nozzles removably disposed in the main body in a radial orientation with respect to the central axis and in heat transferring relation to the heat transfer fluid reservoir, each gas nozzle providing fluid communication between the process gas chamber and a region exterior to the main body.

16. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Rodney McDonald whose telephone number is 703-308-3807. The examiner can normally be reached on M-Th from 8 to 5:30. The examiner can also be reached on alternate Fridays.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam X. Nguyen, can be reached on (703) 308-3322. The fax phone number for the organization where this application or proceeding is assigned is 703-872-9310.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.

RODNEY G. MCDONALD
PRIMARY EXAMINER

RM

March 3, 2003